Reported needs of information resources, research tools, connectivity and infrastructure among African Pharmacological Scientists to improve future patient care and health

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(Accepted for publication Expert Review of Clinical Pharmacology. Please keep CONFIDENTIAL)

Abstract

Introduction: The potentials of Africa for growth and economic transformation through science remains challenging because of existing gaps in knowledge and infrastructure. The Africa Pharmacological Science Gateway project and the Medicines Utilization Research in Africa Group seeks to meet the research needs of African pharmacologists. This study aimed at identifying priority needs that might be met by access to information and tools through e-infrastructure.
Methods: A web-based cross-sectional study among 472 members of pharmacological societies in Africa to obtain information on their research interests and skills, available resources, needs and knowledge gaps. Descriptive analyses were done.
Results: A total of 118 responses from 13 countries were received, mostly from Nigeria (48.3%) and South Africa (21.3%). Respondents had wide ranges of research interests predominantly in drug utilization research.The desired resources included drug utilization research training and tools, pharmacokinetics and pharmacometrics modelling training and tools, drug-drug interaction and medicine prices resources, statistical analysis resources, access to journals, training in specific laboratory techniques, equipment and funding for research-related activities.
Conclusions: Key areas of needs not currently provided by the African Pharmacological Science Gateway e-infrastructure were identified to guide further provision of resources on the e-infrastructure and potentially enhance research capacity within the continent.

Keywords: African Pharmacologists, e-infrastructure, priority needs, Africa Pharmacological Science Gateway.

1. Introduction

Africa constitutes over 15% of the world's population, with Nigeria, Egypt, Ethiopia, and the Congo being the largest countries by population. The continent has a considerable potential for growth and economic transformation through the application of scientific and technological innovations and improved infrastructure driven by research [1, 2]. We have already seen the continent record a number of gains and progress in recent years in this respect, and this is likely to continue. The sub-Saharan Africa (SSA) region more than doubled its yearly research output between 2003 and 2012, raising its global research share from 0.44% to 0.72%, whilst the total number of scientific papers emanating from Africa tripled to over 55,400 a year by 2013 with rising quality and healthcare and agriculture as priority [3]. However, this number still only currently accounts for 2.4% of the world's total publication output [3]. Research outputs in Africa has not been helped by a lack of career structures for scientists and current educational curricula [4].

An estimated 45% of all research activities on the African continent are in the health sciences, a reflection of the prevailing health challenges in the continent [5]. These include among others access, availability and utilization of medicines with the cost of medicines accounting for up to 70% of total healthcare cost in lower- and middle-income countries (LMICs) most of which is expended out-of-pocket [6, 7]. This is particularly important in SSA with a high prevalence of both infectious and non-infectious diseases [8 - 11].

The focus areas of African biomedical research to date has been predominantly in infectious diseases including Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS), tuberculosis (TB), malaria and some neglected tropical diseases, for which research funding is often available [3]; however, this is now changing as non-communicable Diseases (NCDs) are becoming the main cause of death in SSA with growing prevalence rates [8,10].

Despite some progress recorded, Africa's reputation for scientific innovations remains limited. It is a weakness that most of the region's research activities are due to collaboration with non-African partners; nearly 80% in South Africa and 70% in East Africa [3]. This reflects a lack of internal capacity among African scientists to attain the gold-standard of independent and transparently-funded research, enhanced by concerns with career structure and current educational activities, and lack of cross-national collaboration within Africa [4]. However, this is changing.

The few African scientists who have had opportunities of training in high income countries often return to face the problem of limited resources to develop and maintain strong research programs and use the skills they have acquired, thereby potentially becoming scientifically isolated and low overall retention of such individuals in their home countries [12,13,14]. This again is changing with an increasing focus on research as well as publishing in International Journals. In addition, university personnel are becoming increasingly involved with national action plans tackling issues of antimicrobial resistance and NCDs [15 - 17]. This alongside digital initiatives to strengthen the collection of patient data as well as communications between countries.

There have been different initiatives aimed at addressing the digital divide between high and medium and low income Countries (LMIC) such as concerted efforts of the United States of America National Library of Medicine and the Multilateral Initiative on Malaria (MIM) in the beginning of the twentieth century [18] as well as the Pan University Network for Global Health [19]. Similarly, the European Union framework program for research and innovation has also established e-infrastructure projects aimed at achieving a single and open European space for online connections where researchers enjoy leading-edge, ubiquitous and reliable services for networking and computing, as well as seamless and open access to the e–Science environment and global data resources by 2020 and beyond [20]. This project further seeks to increase creativity and efficiency of research and bridge the gaps between researchers in the developed and less developed regions of the world including Africa [20].

Encouragingly, African research communities are increasingly involved in e-infrastructure activities [21, 22]. There are also suggestions of 34 planned or on-going e-infrastructure activities in 13 (22.4%) among 58 African countries in a 2014 survey, which also revealed the focus of user communities to be mainly in natural sciences and life sciences[22]. European Union funded projects such as the joint Trans Africa Network Development (TANDEM) and The West and Central Africa Research and Education Network (WACREN) project, an offshoot of the Africa Connect project, continue to build and operate a potentially world class network infrastructure in Africa, developing state of the art services and promoting collaborations among the research and education communities both regionally and internationally[23]. Furthermore, the potential usefulness of information technology among diverse professional groups and in specific areas of need, including the rational use of medicines, drug supply, continuing medical education and clinical decision support tools and

information, have been established in different parts of the world including rural Africa [15,24-28].

In an attempt to address the challenges faced by African researchers studying the rational use of medicines including both infectious diseases and NCDs, the Medicines Utilization Research in Africa (MURIA) Group was formed [29,30]. Members were linked with other Pharmacological scientists in Africa via an e-infrastructure platform named 'The African Pharmacology Science Gateway (APSG)**'.** The APSG is a collaborative project initiated by the African Institute of Biomedical Sciences and Technology in collaboration with the ei4Africa consortium [31]. Since the needs of African scientists in this field can be complex and diverse, it is essential to identify priority areas for scientists working in this areas as the first step to help improve the situation. Consequently, this study was undertaken to identify the areas of research interests among African pharmacological scientists, the currently available research capacity, skills and resources as well as identifying specific priority areas of need that might be fulfilled by access to information and tools through e- infrastructures. Addressing some of these areas should also improve future research in Africa, translating into improved patient care in the future.

2. Methodology

A cross sectional web-based questionnaire survey was conducted over a six month period from December 2015 to May 2016. The questionnaire was developed by the study team comprising experienced researchers in pharmacological and biomedical sciences. It was pilot-tested among a group of 20 medical scientists in Lagos, Nigeria, different from the target group of respondents to enhance the validity, reliability and robustness of the questionnaire. The questionnaire was modified prior to the commencement of the study and then edited into a web-based *LimeSurvey*® tool using the West and Central Africa Research and Education Network (WACREN) information and communication staff and resources. The *LimeSurvey*® is a free open source software survey (FOSS) tool developed and maintained by LimeSurvey® partners headquartered in Germany (https://www.limesurvey.org). The questionnaire had 4 sections (A, B, C and D). Section A obtained the biographical data and other relevant personal information of participants, Section B obtained information on their current research areas and interests, and Section C asked for details regarding available research skills and resources including those that are transferable, i.e. those that can be shared and taught to others. Section D obtained information on the expressed needs and knowledge gaps of the respondents [32].

Potential respondents were identified through available e-mails of members of pharmacological societies known to the authors. These included members of the MURIA Group, members of the International Union of Basic and Clinical Pharmacology (IUPHAR) including the Pharmacology for Africa Initiative (PharfA), the West Africa Society for Pharmacology (WASP) and The South African Society for Basic and Clinical Pharmacology (SASBCP) (See http://www.iuphar.org/index.php/societies). In addition, individuals known to the research team who had participated in African regional pharmacological meetings and training courses were also included.

Potential participants were invited through their 'emails' with background information about the study, instructions and a link to the web-based survey[32]. A total of 472 individuals were invited to participate in the survey with a spread across West, South, East and North Africa

sub-regions. Pre-programmed reminders were sent to these individuals at three time points with a six weeks interval. Specific target groups included the following:

- MURIA Group: An inter-disciplinary and multi-national group of academic and healthcare professionals from various countries across Africa, Europe and North America who came together in January 2015 to foster research in various aspects of drug utilization research in Africa. MURIA had a total of 102 members in December 2015, which has since grown to over 200 in June 2018. The group has been active since inception including four Pan African scientific symposia, country specific meetings, an appreciable number of scientific publications to its credit, as well as a number of planned and on-going research projects in different African countries [29,30,33].
- PharfA: An initiative which started in 2006 with the aim of organising and promoting pharmacology in all countries in Africa. The group seeks to stimulate and coordinate local societal organisations, promote research in basic and clinical pharmacology and the teaching of pharmacology. An activity of this group is the development of a database and network of pharmacologists (including Pharmacology Training Institutions) in Africa. The group derives its membership from national pharmacology societies in Africa and it is affiliated to IUPHAR (Available at: http://iuphar-africa.org/en/member-societies/)
- WASP: This society was founded in 1971 for the purpose of advancing the science of Pharmacology and Allied Sciences in the West Africa sub-region. Members are from the whole sub-region and include medical doctors, veterinarians, pharmacists, molecular biologists, biochemists, phytochemists, and botanists. The society holds annual conferences geared towards sharing new ideas and human resources development in research, teaching and community services related to the science of pharmacology. It is a member of the International Union of Basic and Clinical Pharmacology (IUPHAR) (Available at: http://www.waspsoap.org/)
- SASBCP: A member of the International Union of Basic and Clinical Pharmacology (IUPHAR) established in 1966 with over 140 active members. The society promotes the science of basic and clinical pharmacology in general with support from academia, industrial and professional practice spheres. It is actively involved in promoting pharmacology among young scientists and was instrumental to the formation of PharfA (Available at: http://www.sapharmacol.co.za/)

At the close of the survey, the data obtained were downloaded from the survey site and analyzed using The Statistical Package for Social Sciences (SPSS) 17.0 version. The results of the analysis were summarized mainly into categorical variables expressed as proportions and percentages.

2.1 Ethical Consideration

The survey being non-interventional and non-controversial in nature fell within the types of study granted waivers by the applicable ethics and competent authorities within the study areas. However, participation was voluntary and this was clearly stated in the invitation to participate and only willing individuals gave responses.

3. Results

3.1 Respondents

A total of 118 responses were received, giving a response rate of 25% (118/472). Of the 118 responses, 50 were complete while 68 were partially completed. The 89 respondents who mentioned their country of residence were from 13 countries; 11 African countries with a

spread across the sub-regions, as well as Canada and Finland. The majority of respondents were from Nigeria; 43 (48.3%) and South Africa; 19 (21.3%) as shown in Table 1. The respondents have their background academic qualifications in Basic Pharmacology (BSc), Pharmacy (B.Pharm) and Medicine (MD) (Table 2).

3.2 Reported Areas of Research Interests, Transferable Skills and Available Resources

A number of current research interests and activities were listed by the respondents covering a wide spectrum of areas in basic and clinical pharmacology as well as other biomedical research areas as shown in categories in Table 3a. Specific areas of interests and research activities are shown in Table 3b. Predominant areas included drug utilization research and pharmacoepidemiology (11.8%), pharmacokinetics, pharmacodynamics and pharmacometrics (7.1%), diabetes mellitus and metabolic syndrome/endocrine pharmacology (7.1%), toxicology (6.2%), ethnopharmacology (6.1%), neuropharmacology and HIV/AIDS research (5.6%).

The skills possesed by respondents which could be taught to others and propagated are referred to as 'transferable skills', and are listed in Table 4. These ranges from various clinical research skills, laboratory and analytical skills and techniques as well as human resources in the form of postgraduate students who assist in research projects.

3.3 Desired Resources and Knowlegde Gaps

Table 5 shows the various resources desired by the respondents. Training needs were high on the agenda including training in specific research areas such as drug utilisation and qualitative research. Other needs expressed were access to specific tools and resources on-line, various laboratory equipment and infrastructure, as well as funding and networking opportunities.

3.4 Highlights of the Responses of Respondents Residng Outside Africa

There were 3 respondents from countries outside Africa: 2 from Canada and 1 from Finland. These were African Pharmacological Scientists residing in these countries at the time of the survey. The response from the participant from Finland was incomplete giving no information about research interests, transferable skills, available resources and knowledge gaps. However, the two respondents from Canada had the following research areas: oncology, drug discovery, diabetes, vascular pharmacology and medical education. The two respondents expressed availabily of skills and relevant tools in their areas of research and stated no desired needs or knowledge gaps.

4. Discussion

This web-based survey of the needs for research tools, information resources, connectivity and infrastructure, necessarily focused on African pharmacological scientists given the high prevalence of both infectious and non-infectious diseases in SSA and the need to enhance the rationale use of medicines [8-11]. The most frequently mentioned pharmacological science-based needs were on-line training programmes in drug utilization research techniques, pharmacokinetics modelling and pharmacometrics training, access to calculation tools to assess adherence to recommended lists of medicines, access to pharmacokinetics and pharmacometrics software, access to drug-drug interactions software and access to international medicine prices. In addition, increased knolwedge of health economics

including budget impact analyses. Other desired resources included laboratory equipment and training in specific laboratory techniques, access to journals and funding for research-related activities (Table 5).

Encouragingly, we had respondents from Western, Northern, Eastern and Southern African sub-regions (Table 1). As mentioned, the three respondents from outside Africa were African scientists who were away from their countries at the time of the survey as we do see a number of African scientists becoming migratory in search of training and other desired opportunities [3]. Despite this, the majority of the respondents were from Nigeria and South Africa reflecting the fact that Nigeria is the most populous SSA country while South Africa currently takes the lead in scientific activities among SSA countries [2, 3].

The response rate of 25% is consistent and perhaps higher than the documented average response rate obtained from similar studies. Surveys distributed internally (i.e to employees) are said to have generally a higher response rate of 30-40% compared to an average of 10-15% for external audiences, which is similar to our study[34]. Approximately one-third of the total number of respondents (Table 2) were currently in training. This is perhaps not surprising as such groups are expected to express enthusiasm towards opportunities that could potentially meet their training needs. While the distribution of the qualifications of the respondents in this study can not be said to be representative of the current state of human resources in the scientific sectors in Africa, or the edcational levels of African pharmacological scientists in general, it may be suggestive of the prevailing situation in some areas. Kokwaro has previously stated that the majority of prominent African medical scientists of the sixties and seventies are either retired or will soon retire to leave behind a vacuum characterised by institutions which are so run down that proper research and training are no longer feasible, and are unable to produce enough well trained young medical scientists as well as undertake cutting edge standards to sustain the legacies of the past years [4]. However, the findings of 20% each of respondents in the categories of BSc/PhD holders and combination of MD/PhD and MD/Postgraduate fellowship holders is noteworthy. These are individuals who have obtained terminal degrees and qualifications and are therefore expected to be able to make meaningful contributions to science given the necessary infrastructure and enabling environment, which is now happening.

The current areas of research interests and activities include various aspects of drug reseach, the basic medical sciences, clinical sciences, infectious and tropical diseases, NCDs, medicinal plants, toxicology, genomics, special population pharmacology and other areas (Tables 3a and 3b). Drug utilization research was the most frequent area of interest among the respondents, which perpahs reflects a number of MURIA members completing the survey. In addition, the irrational use of medicines, and its consequences, are a growing challenge across Africa [7, 35]. This has already resulted in a number of research activities including documenting the existence and functionality of drug and therapeutic committees across African countries, documenting pharmacovigilance activties among hospitals with the aim of establishing pertinent programmes to address current concerns including the over reliance on pharmaceutical companies for information on medicines [36-41], as well as the current state of antimicrobial stewardship programmes as a basis for developing programmes to improve the future use of antimicrobials in Africa given current concerns [42-44]. Such activities should help to reduce AMR rates, adverse drug reactions and associated increased hospitalization rates and death, and unaffordable costs of medicines among a population that predominantly pays ‘out of pocket’. As a result, start to address this major challenge among African countries. The current identified research interests among the surveyed African

scientists are in part informed by the prevailing health challenges as well as areas of priorities of funders who are mostly external [3, 4]. Hence, the pattern of research interests seen among the respondents.

A prevalence of 7.1% of the researchers in Diabetes Mellitus, Metabolic Syndrome and Endocrinology Pharmacology Researches is also highly instructive, and an indication of the current epidemiological transisition being experienced in developing nations as a consequence of rapid westernization of lifestyle and urbanization resulting in reduced physical activity and over consumption of energy-dense foods. This leads, as mentioned, to a higher prevalence of NCDs including diabetes mellitus and hypertension, which together with concerns with adherence, are subjects being actively researched by MURIA members and others [10, 45-54]. As discussed, HIV/AIDS research is still a key area in SSA with 5.6% of respondents active in this area of research as seen by MURIA member activities in Namibia and South Africa [55-58]. This is explainable partly by the high prevalence rates of HIV in SSA and partly by reseachers interests occasioned by the priorities of the funders [3,11]]. This is likely to continue.

There were respondents who stated possesing a number of research skills and laboratory competencies that are transferable, which is also encouraging. These, however, might be sparsely and unevenly distributed across Africa, which is a concern. In addition, the corresponding expression of desires by the majority of the responders for provision of a wide array of laboratory equipment is indicative of the possibility that these expressed skills might have been dormant or sub-optimally utilized owing to lack of equipment and infrastructure. There is a need to further strenghten identified available capacities and resources and promote the sharing of such across the continent. We will be monitoring this in the future.

The respondents expressed an overwhelming desire for training in identified areas of knowledge gaps in the form of on-line courses as well as the provision of on-line resources and tools to facilitate their research activities (Table 5). There was also expression of the need for funding support and grants for research, attendance at international conferences, funding for open access scientific publications in peer reviewed journals, as well as a passionate desire for networking and collaboration with scientists outside Africa. These are clear indications of a lack of adequate support for research within Africa and the existence of gaps to be addressed. Contrarily, the respondents from outside Africa expressed the availabily of skills and relevant tools in their stated areas of research and no desired needs or knowledge gaps. These further highlights the differences in the work environments between African countries and the advanced nations, which urgently needs addressing.

Overall, African pharmacological scientists will benefit greatly from e-Infrastructure platforms providing drug utilization research tools and trainings, a database of international medicine prices and costing tools, pharmacokinetic, pharmacodynamics and pharmacometric tools and trainings, on-line resources on statistical analysis, drug-drug interactions software, access to journals and enhanced opportunities for networking with the global research communities in relevant areas. These are starting to be addressed through initiatives such as MURIA as well as the recent formation of the African Chapter of the International Society of Pharmacoepidemiology [59].

Other areas including access to guidelines and on-line support for decision making in health care will also be relevant to such projects [14,18]. These will potentially reduce the “brain

drain" syndrome that has plagued the African scientific communities in recent years ,and revolutionize the pursuits of pharmacological sciences. This includes key areas such as the integration of biomedical information enhancing for instance the rational use of medicines which will benefit all SSA communities [60]. Key areas will also include assessing prescribing against agreed national guidelines including using tools such as DU90% as well as assessing the extent of off label prescribing and potential drug-drug interactions as a prelude to developing future activities based on on-line support [61-67].

4.1 Application of Results to the development of the Africa Pharmacological Science Gateway (APSG)

The Africa Pharmacological Science Gateway as presently constituted has the following sections already operational: Genomic & Bioinformatics and Pharmacokinetics & Pharmacometrics Resources while the following sections are still under development: Bioanalysis, Drug Analysis & Metabolism, Clinical Trial Sciences, Digital Library and Multimedia contacts & e-Learning Tools [31].

The expressed pharmacological science-based needs by the respondents have been met in part with the availability of pharmacokinetics and pharmacometrics resources. However, there is currently no specific availability of resources on Drug Utilization Research (DUR) which was the most frequently expressed area of need in this survey on the APSG platform. However, the recent instigation of the ISPE African chapter with access to a wide range of resources [59], and combined with the increased availability of training courses at MURIA workshops with all the materials available on-line afterwards are addressing these needs. The inclusion of DUR tools in the APSG e-infrastructure will further strenghten these efforts. Other key areas include issues of prices of medicines across SSA and internationally for comparative purposes as well as tools for assessing drug-drug interactions as expressed by respondents. These are considerations for the future.

Furthermore, the section on Digital Library being developed within APSG could accommodate access to journals while the section on Multimedia and e-Learning Tools could be used to meet the various training needs expressed in a number of areas including drug utilization research methods, qualitative research methods, statistical analysis, pharmacokinetics and pharmacometrics modelling. Other training needs in laboratory techniques including advanced tissue culture and DNA sample analysis, as well as equipment and infrastructure needs, could be addressed with a different approach.

Limitations of the study

We recognise that a convenient sampling method limited to identifiable members of pharmacological societies in Africa may not be totally representative of the community of pharmacological scientists currently working in Africa. In addition, the response rate was perhaps biased by participants who were members of MURIA group whose primary interests is in Drug Utilization Research. This may in part explain the highest area of interest obtained in this research area.

Nevertheless, we believe our findings are robust and point to the need for co-ordinated research activities and funds to address the high prevalence of both infectious and non-infectious diseases in SSA as the countries strive towards universal healthcare recognising that medicines are a key part of this.

4. Conclusion

Our study, employing a web-based survey, has proven useful in identifying key priority areas of need among African researchers within the field of pharmacology to improve their contribution to enhance the care of patients through enhancing the rational use of medicines. The identified areas of need will guide further provision of resources on the e-infrastructure projects being executed through the African Pharmacological Science Gateway with the potential of assisting in building research capacity and developing networking opportunities among African countries in the future. Furthermore, information generated could also assist in mapping available resources (human and material) that could be used to facilitate collaborations and optimize the use of scarce research resources within Africa, building on current collaborative research programmes. This should benefit patient care in the future.

This web-based survey approach could also be applied to identifying areas of needs of other groups of researchers in different fields within the African continent.

Availability of Data and Material:
All data generated and analysed during this study are included in this published article.

Competing Interests
The authors declare they have no competing interests.

Article Highlights Box

- Despite the progress being made in recent years, there still exists digital, knowledge and infrastructural gaps in Africa countries which if addressed could unlock the potentials of these nations for growth, economic transformation and improved heath care driven by researches targeted towards solving the multiple problems confronting the continent.
- The African Pharmacological Science Gateway (APSG) and the Medicines Utilization Research in Africa (MURIA) Group sought to identify through a web based survey the currently available research capacity, skills and resources as well as specific priority areas of needs of African Pharmacological Scientists that could be fulfilled by access to information and tools through e- infrastructures so as to improve their research capacities that could translate into improved patient care in the future.
- A total of 118 out of the 472 invited scientists responded (25% response rate) indicating diverse areas of research interests and activities that reflects the prevailing health challenges of the continent as well as priority areas of donor agencies
- The expressed priority needs and knowledge gaps included training in specific research areas such as drug utilisation and qualitative research, access to specific tools and resources on-line, various laboratory equipment and infrastructure, as well as funding and networking opportunities.
- The identified areas of need will guide further provision of resources on the e-infrastructure project being executed through the African Pharmacological Science Gateway with the potential of assisting in building research capacity and developing networking opportunities for African countries which should benefit patient care in the future.

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Bibliography Annotations:

“**” = ‘’of considerable interest (References 4 depicts the enormity of the challenges facing the African countries with respect to cutting edge scientific knowledge and enabling environment for research productivity stating the factors responsible for the evolution of these challenges while attempting to proffer some solutions while Reference 22 reveal the level of uptake of information technology driven e-infrastructural activities in Africa which is an indication of some progress.

‘*’ = ‘of interest’ (Reference 24 is of interest because it reveals the prospects of uptake of Information Technology driven tools for rational use of medicines in rural Africa setting while Reference 29 reporting the formation of the multi-disciplinary cross-national group; The Medicines Utilization Research in Africa (MURIA) group which has continues to make progress in promoting rational use of medicines across Africa is an illustration of the great potentials in Africa and the benefits of cross-national collaborations.